INTRODUCTION

Chordates are neither the most diverse nor the largest of the animal phyla, although in terms of the number of species, they come in a respectable fourth behind arthropods, nematodes, and molluscs. Living chordates consist of three groups of unequal size: cephalochordates (Amphioxi or lancets), urochordates (tunicates or sea squirts), and the largest group, the vertebrates (fishes, amphibians, reptiles, and mammals).

The chordates are animals characterized by the presence of a notochord, a dorsal gelatinous stiffening rod, present during some stage in development, tubular nerve cord, situated dorsally to the notochord and pharayngeal gill slits. The chordate include animals that can be grouped into two major subdivisions (subphyla) the **vertebrata (craniata)** and **protochordata (Acraniata).** The vertebrates are the best known and most numerous representatives of this phylum, exceeded in number of species only by arthropods and molluscs, and widely distributed in all types of habitats. The other chordates, the Acraniata are limited to marine environments.

The vertebrata are the animals with a backbone, but this is not exactly correct. For the "round-mouthed" eels (Cyclostomes) including the lamprey and hagfish the axial skeleton is a cylindrical rod or cord consisting of somewhat gelatinous internal substance enclosed by a sheath of tough fibrous tissue. The notochord itself is quite unsegmented. Its fibrous sheath extends upwards on either side to enclose the dorsal nerve cord. In the neural arch of fibrous tissue formed in this manner minute rods or plates of cartilage are embedded. The little cartilage have been interpreted as vertebrae, but they are merely rudiments of them. Thus, here are animals

without a "column", i.e., a longitudinal series of definitely formed vertebrae articulated to one another, and yet they are called vertebrates.

MAIN CHARACTERISTICS OF CHORDATES

1- NOTOCHORD

The notochord is a slender rod that develops from the mesoderm in all chordates. It lies dorsal to the coelom but beneath and parallel to the central nervous system (brain and spinal cord). The phylum takes the name Chordata from this structure. Typically, the notochord is composed of a core of cells and fluid encased in a tough sheath of fibrous tissue. Sometimes the fluid is held within swollen cells called vacuolated cells; other times it resides between core cells of the notochord. The notochord has the mechanical properties of an elastic rod, so it can be flexed laterally from side to side but cannot be collapsed along its length like a telescope.

The notochord continues to be an important functional member throughout most groups of chordates. Only in later forms, such as in bony fishes and terrestrial vertebrates, is it largely replaced by an alternative functional member, the vertebral column. Even when replaced by the vertebral column, the notochord still appears as an embryonic structure, inducing the neural tube to develop above it into the brain and spinal cord and serving as a scaffold for the growing embryonic body. In adult mammals with a full vertebral column, the notochord is reduced to a remnant, the *nucleus pulposus*, this is a small core of gel-like material within each intervertebral disk that forms a spherical pad lying between successive vertebrae.

2-PHARYNGEAL SLITS

Another of the chordate features is the pharyngeal slits. The pharynx is a part of the digestive tract located immediately posterior to the mouth. During some point in the lifetime of all chordates, the walls of the pharynx are pierced, or nearly pierced, by a longitudinal series of openings, the pharyngeal slits (also called pharyngotremy, literally meaning "pharyngeal holes"). The term *gill slits* is often used in place of pharyngeal slits for each of these openings, but a "gill" proper is a specialized derived structure of fish and larval amphibians composed of tiny plates or folds that harbor capillary beds for respiration in water. In such vertebrates, gills form adjacent to these pharyngeal slits. The slits are openings only, often with no significant role in respiration. In many primitive chordates, these openings serve primarily in feeding, but in embryos they play no respiratory role; therefore gill slit is a misleading term.

Pharyngeal slits may appear early in embryonic development and persist into the adult stage, or they may be overgrown and disappear before the young chordate is born or hatched. Whatever their eventual embryonic or adult fate, all chordates show evidence of pharyngeal slits at some time in their lives.

3-ENDOSTYLE OR THYROID GLAND

The endostyle is a glandular groove in the floor of the pharynx. It is involved in filter feeding. The thyroid gland is an endocrine gland that produces two major hormones. The thyroid gland, like the endostyle, arises embryologically from the floor of the pharynx. And the thyroid gland, like the endostyle, is involved in iodine metabolism, further suggesting a homology between the two, with the endostyle, being the phylogenetic predecessor of the thyroid. Supporting this, the jawless fish called lampreys

have a true endostyle when they are young larvae, that becomes a true thyroid when they become adults. Thus, all chordates have endostyles (urochordates, cephalochordates, larval lamprey) or thyroids (adult lamprey, all other vertebrates).

4-DORSAL AND TUBULAR NERVE CORD

The dorsal hollow nerve cord derived from ectoderm. The central nervous system of all animals is ectodermal in embryonic origin, but only in chordates does the nerve tube typically form by a distinctive embryonic process, namely, by invagination. Future nerve tube cells of the early chordate embryo gather dorsally into a thickened neural plate within the surface ectoderm of the back. This neural plate of cells folds or rolls up and sinks inward from the surface (invaginates) as a tube to take up residence dorsally within the embryo, just above the notochord. A nerve cord produced from a thickened plate by invagination is also called a neurulated nerve cord.

5-POSTANAL TAIL

Chordates possess a postanal tail that represents a posterior elongation of the body extending beyond the anus. The tail is primarily an extension of the chordate locomotor apparatus, the segmental musculature and notochord.

6-THE VENTERAL HEART

The heart is ventral in position and flow of blood in the dorsal vessel is from the anterior to the posterior end. In higher vertebrates the heart is contained within a modified part of the coelom termed the pericardial cavity, the bounding wall of which called pericardium

7- DIVISION OF COELOM

The body cavity in the embryo is known by the comprehensive name of the coelom, but it is divided into many parts. Of these there are two dorsal series, one on each side of the nervous system, which arise from the cavities (myocoel) of what are known as the somites of the body. There are also two large ventral divisions which extend from the region of the head to that of the future pelvis, one division for each side of the body. These two parts are not divided into segments at all, though the cavities of all the segments are primitively connected with these two main divisions.

Comparatively early in the development of the two main cavities become connected with each others forming splanchnocoel, which surrounds the heart of the embryo (pericardial cavity) and extends through the future abdominal region (abdominal cavity); the two regions being separated by the transverse septum. It is considered to be one of the most striking of all morphological peculiarities by which vertebrates are distinguished from invertebrates.

UROCHORDATES

Urochordates generally show all five shared derived chordate characteristics: notochord, pharyngeal slits, endostyle, tubular nerve cord, and postanal tail, at some point in their life histories Urochordates are specialists at feeding on suspended matter, especially very tiny particulate plankton. In most, the pharynx is expanded into a complex straining apparatus, the branchial basket. In a few species the filtering apparatus is secreted by the epidermis and surrounds the animal. All species are marine. Urochordates are divided into several major taxonomic classes. Ascidiacea are sessile as adults, but have swimming larvae, whereas the taxa Larvacea and Thaliacea are permanently pelagic and drift in the plankton, unattached to any fixed substrate.

Urochordate literally means "tail backstring," a reference to the notochord. The familiar name, tunicates, is inspired by the characteristic flexible outer body cover, the tunic. It is secreted by the underlying epidermis with contributions from scattered cells within the tunic itself. This tunic, sometimes referred to by the more general name test, characterizes the urochordates.

CLASS: ASCIDIACEA (TUNICATA) i.e: ASCIDIA

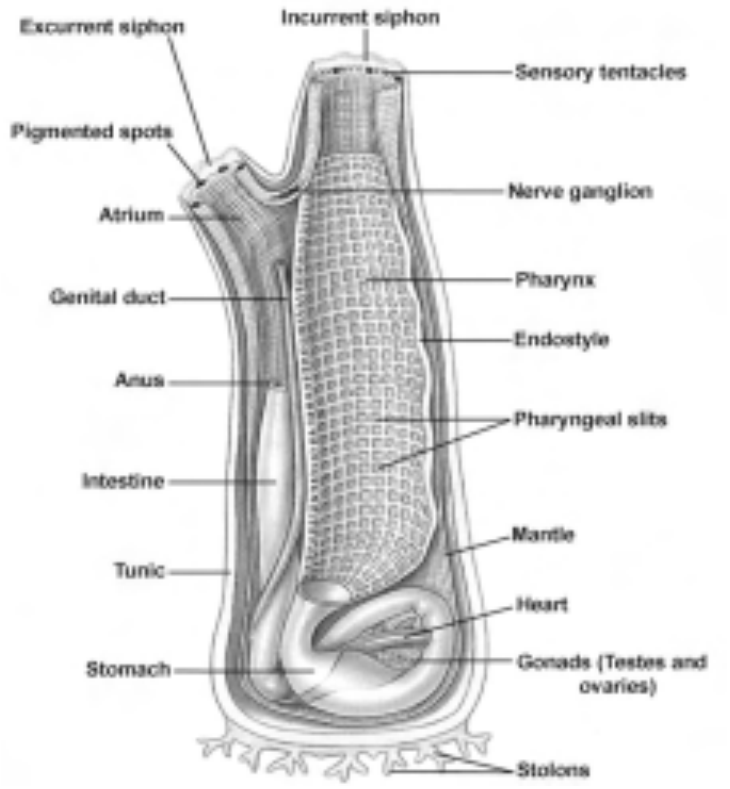
Adult

The entire body is covered by a tough cuticular covering called tunic or test. The tunic, composed of a unique protein, tunicin, and a polysaccharide similar to plant cellulose, forms the body wall of an ascidian adult secreted by **morula cells** in circulating blood. The tunic is responsible for the definite form of the animal and forms the foot at the postero-ventral region.

DIGESTIVE SYSTEM

The alimentary canal comprises a narrow tubular buccal cavity or branchial siphon, a large modified pharynx or branchial siphon, a short oesophagus, stomach, intestine and rectum that finally opens into atrial cavity. Two-lobed liver and the pyloric gland serve as gland associated with digestion.

Incurrent (branchial) and excurrent (atrial) siphons form entrance and exit portals for the stream of water that circulates through the body of the tunicate. Tiny, fingerlike sensory tentacles encircle the incurrent siphon to examine the entering water and perhaps exclude excessively large particles before water enters the branchial basket. The complex pharyngeal slits, the stigmata, sieve the passing water before it flows from the branchial basket into the atrium, the space between basket and tunic. From here, the current exits via the excurrent siphon.

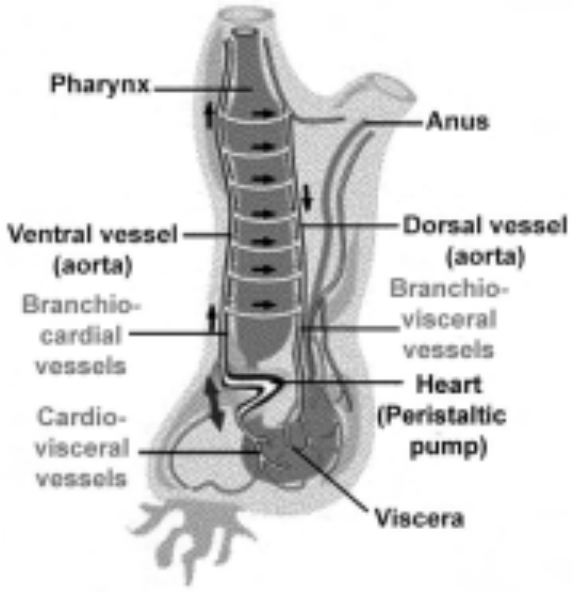


External features and a cross section of the Ascidia.

Rows of cilia line the branchial basket. The mucus-producing endostyle, a mid-ventral food-groove, is connected by continuous ciliated bands or tracks around the inside to the dorsal lamina. Particulate matter is extracted from the passing stream of water by a netlike sheet of mucus lining the branchial basket. The rows of cilia collect the food-laden mucus to move it from ventral to dorsal, delivering it to the dorsal lamina, which in turn conveys it posteriorly to the gut.

CIRCULATORY SYSTEM

The sea squirt's heart, located in the body near the pharynx, is tubular, with a single layer of muscle-like striated myoepithelial cells forming its wall. The surrounding pericardial cavity is the only remnant of the coelom. Contraction of the heart pushes blood out to the organs and tunic. After a few minutes, the flow reverses to return blood along the same vessels to the heart. Unlike the vertebrate circulatory system, there is no continuity between the heart myoepithelium and the blood vessels. Ascidian blood vessels are not lined by an endothelium. The blood contains fluid plasma with many kinds of specialized cells, including amoebocytes, lymphocytes, nephrocytes and morula cells.



Ascidian blood circulation

There are three main systems of blood channels (the branchio-cardial, the cardio-visceral and the branchio-visceral). From the ventral end of the heart originates the branchio-cardiac vessels which gives a branch to the test and then runs along as a ventral aorta. At the other end arises the cardio-visceral vessels which gives a branch to the test then breaks up into number of sinuses which supplies the alimentary canal and general viscera. The visceral blood vessels communicate with a third great sinus the branchio-visceral vessels which run forward along the dorsal edge of branchial basket forming the dorsal aorta

NERVOUS SYSTEM

The nervous system of the adult tunicate is very poorly developed for a chordate.

The adult nervous system consists of a brain-like cerebral ganglion located between the siphons. Nerves that pass to the siphons, branchial basket, and visceral organs arise from each end of the ganglion. Beneath the ganglion lies the subneural gland, a structure of unknown function that is left over from the larva and joined to the branchial basket via a ciliated funnel. There are no well-defined sense organs in the adult tunicate, but sensory cells of various kinds occur in several organs such as siphons, velum and other movable parts:

(1)- The pigments spots or "ocelli" formed of modified ectoderm cells imbedded in red and yellow pigment, occur between the branchial and atrial siphons.

(2)- The tentacles at the base of the branchial siphon are supplied with nerves and special sensory cells and are very sensitive.

(3)- The epithelial cells covering the vascular ampullae are supplied with fine nerve fibrils and are tactile in nature.

EXCRETORY SYSTEM

In Ascidia a mass of large clear walled vesicles, the renal vesicles, and may sometimes extend over the adjacent walls of the intestine. The renal organ is without a duct. The vesicle represents the vestiges of the coelom and each is formed of cells which eliminate nitrogenous wastes from the blood circulating cells called (**nephrocytes**).

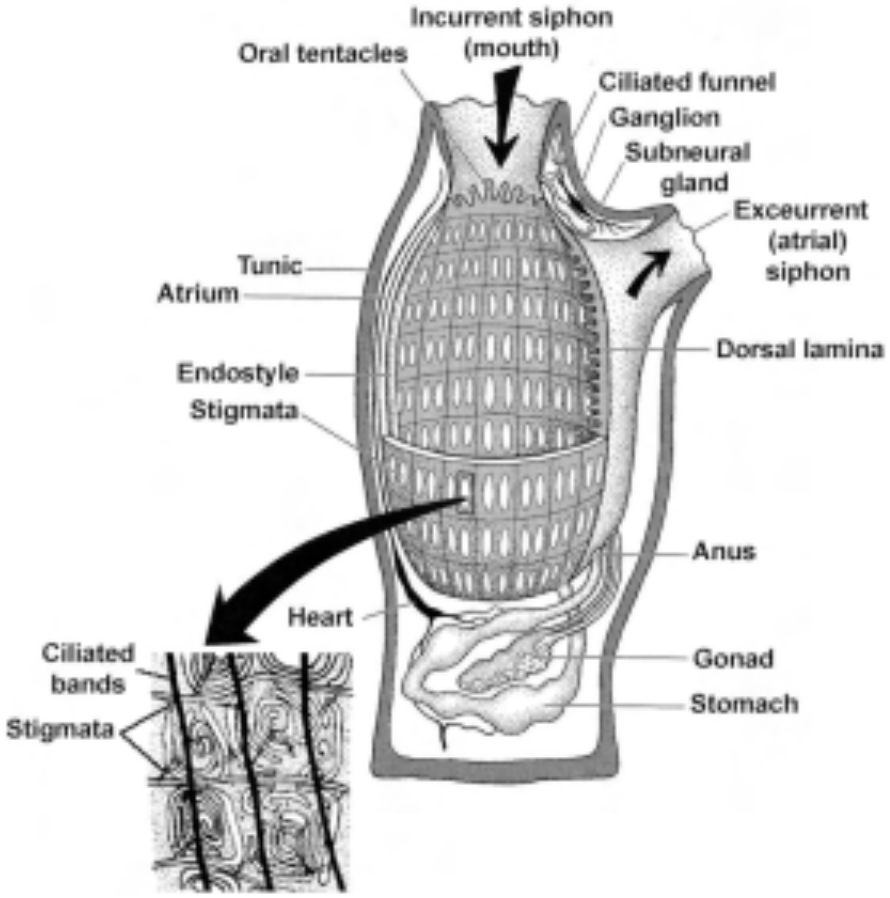
The waste is deposited in the lumen in the form of concentrically laminated concretions of a yellowish or brownish colour. These deposits carry uric acid. The nitrogenous waste product may be stored instead of being excreted. The renal organ may differ in position and structure in other tunicates.

REPRODUCTIVE SYSTEM

All ascidians are hermaphrodites; both sexes occur in the same individual (monoecious), although self-fertilization is rare. Solitary ascidians reproduce only sexually, while colonial ascidians reproduce sexually and asexually. Asexual reproduction involves budding. The root-like stolons at the base of the body may fragment into pieces that produce more individuals, or buds may arise along blood vessels or viscera. In colonial species, buds even appear in the larva before metamorphosis. Such budding gives the tunicate a way to propagate rapidly when conditions improve. In some species, buds seem especially hardy and are adept at surviving temporary adversity.

The **ovary** is a much branched gland and contains a cavity derived from embryonic coelom. The ova are budded off from its walls and when mature fall into the cavity. The ova come out through the oviduct and runs forward alongside the rectum opening into the peribranchial cavity near the

anus. The **testis** is composed of a great number of delicate branched tubules which ramify over the ovary and the adjacent parts of the intestinal walls. These tubules terminate in oval swellings and near to the rectum and opening into the peribranchial cavity near the anus.



Section of Ascidia showing branchial basket, digestive, reproductive and nervous system

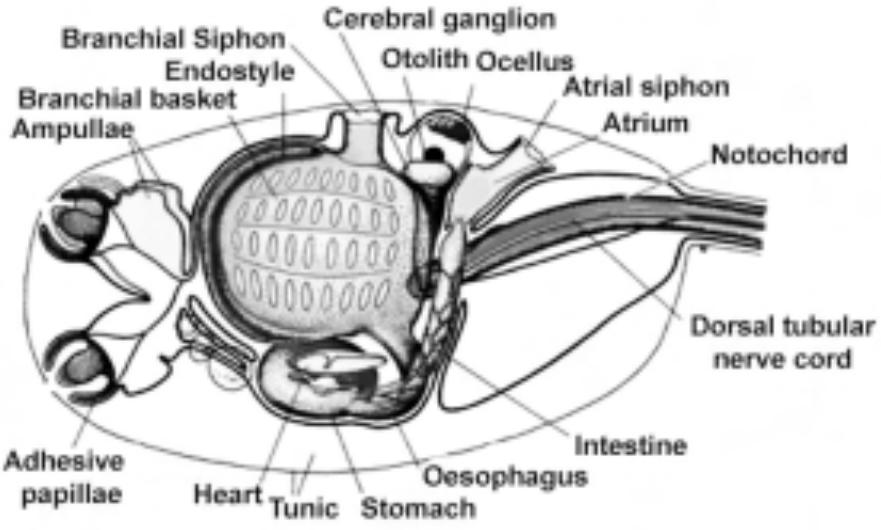
LARVA

The larva, sometimes called the **ascidian tadpole**. Only the larval stage exhibits all five chordate characteristics simultaneously. The larvae of tunicates have adhesive papillae at the front that secrete a sticky attachment

substance. Once attached, metamorphosis is quick. Within minutes the tail begins to be resorbed, the larva rotates to bring the siphonal openings into correct orientation, and the branchial-basket filtering system becomes functional. In addition to the tail being resorbed, other structures useful in swimming and navigation in the larva are resorbed or reduced in size. In general, there are 2 main groups of structures in the larva:

1)- **Transitory larval organs**: notochord, dorsal tubular nerve cord, tail, adhesive papillae, and various ganglia and sensory organs (e.g., ocellus or eyespot). These structures function in swimming, sensory input, and attachment, and are lost or resorbed during metamorphosis.

2)- **Prospective juvenile/adult organs**: siphons, branchial basket, endostyle, ampullae, gut, cerebral ganglion, and heart. These structures are in an arrested state of development in the larva, and become functional shortly after metamorphosis.

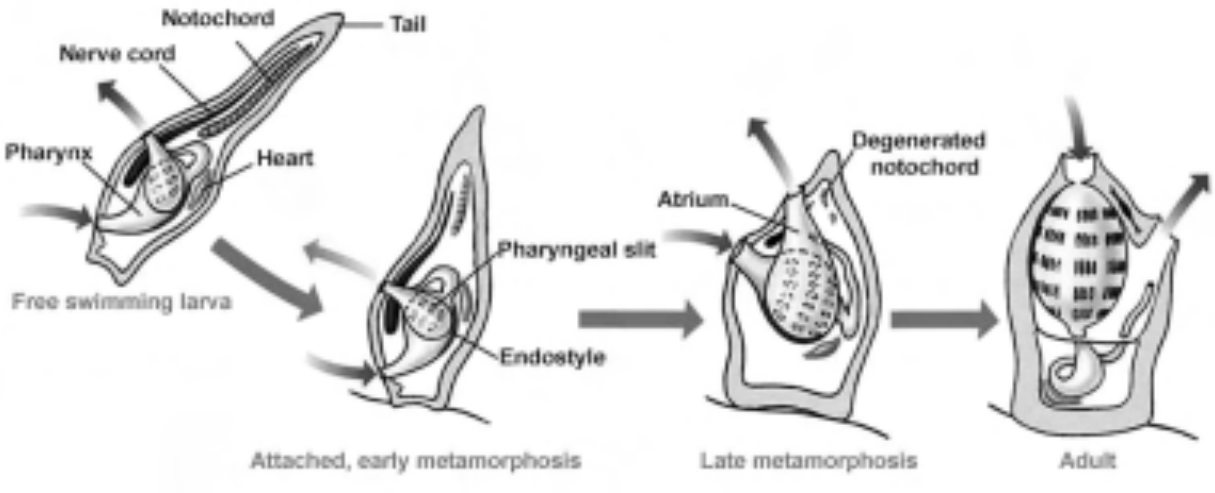


Ascidian larva showing transitional larval and prospective adult organs

The changes involved in the retrogressive metamorphosis are:-

- Increase in the number of pharyngeal stigmata.

- Diminution and complete disappearance of the tail with contained notochord and caudal part of the nerve cord.
- The disappearance of the sense organs.
- Dwindling of the central part of the nervous system to a single ganglion.
- Formation of reproductive organs.



Ascidian metamorphosis with complete disappearance of notochord and nerve cord in adult.